Importance of Local-Scale Emissions Inventories

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Introduction

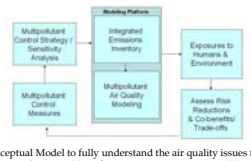
Photochemical air quality models are commonly used in regulatory and policy assessments to estimate pollutant concentrations and deposition of both inert and chemically reactive pollutants over large spatial scales. These models generally are run for horizontal grid resolutions of 36 km and 12 km. Several recent assessments have revealed the need for air quality predictions at resolutions finer than 12 km to be able to resolve important local-scale gradients in pollutant concentrations. For example, the regulatory impact assessment (RIA) for the recent PM2.5 NAAQS suggested that modeling at 12 km may not adequately capture the health and economic risk-based benefits achieved in an area which relies on controlling local sources to achieve attainment. This was also recognized in the "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze" (EPA, 2007), which included discussion of modeling for a "local area analysis" for PM2.5 to capture these benefits. In addition to PM2.5, there are many toxic species which exhibit "hot-spots" or areas of high concentration, usually near a source of the toxic air emissions. These "hot-spots" are usually on scales that can not be resolved with 12 km modeled data. Because of this, the current National Air Toxics Assessment (NATA) and proposed next phase - the National Air Pollution Assessment (NAPA), which would include both air toxics and criteria pollutants, both provide a need for local-scale toxics and criteria pollutant concentrations.
The National Research Council (NRC) recommended that the United States ***transition from a pollutant-by-pollutant approach to air quality management to a multi-pollutant, risk-based approach.***

➢There is an increasing need to provide multi-pollutant & multi-resolution air quality information
- Multi-pollutant: Release, control, and chemical formation of pollutants are interrelated
- Multi-resolution: Address regional and local-scale impacts of regulations and policies (e.g. PM2.5 SIPS, NATA)

The Detroit urban area was selected as a 'proof of concept' to develop and undertake multi-pollutant, risk-based analyses.

Project Approach

Detroit Multi-pollutant Pilot Study: Analytical Framework



➢Develop a Conceptual Model to fully understand the air quality issues for the area
- Are emissions dominated by a few source types or more widely distributed throughout the source population?
- What are possible sources for co-control?
- How does the atmosphere respond to reductions in certain pollutants?
- What controls have the greatest effect on reducing key pollutants?

Why Detroit?

➢Multi-pollutant Issues
- PM2.5, Ozone, Toxics

➢Rich in technical data, research and analyses
- Detroit Air Toxics Initiative (DATI)
- Detroit Exposure and Aerosol Research Study (DEARS)
- LADCO, Region V and Michigan DEQ
- PM National Ambient Air Quality Standards

Results

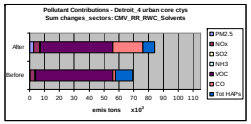
Emissions Inventory and Modeling

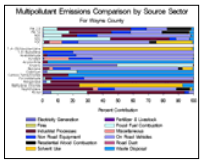
Southwest Detroit: Local PM Influences

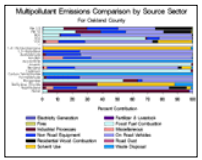
DATI project monitored over 200 compounds from April 2001 – April 2002.
- Analysis identified 13 chemicals as highest concern: methylene chloride, naphthalene, benzene, acrylonitrile, formaldehyde, 1,4-dichlorobenzene, arsenic, carbon tetrachloride, 1,3-butadiene, acetaldehyde, cadmium, nickel, and manganese
- Acrolein considered an important toxic based on DEARS
- Diesel exhaust may be important pollutant to focus on for mitigation of air toxics health risks

➢2002 NEI: Integrated toxics and criteria emissions information
➢Looked for largest multi-pollutant emission sources with potential high relative risk for cancer and non-cancer
➢Prioritized 34 facilities for review; GIS-based investigation for non-point sources: industrial coal combustion, residential wood combustion, charbroiling
➢Looked for local activity surrogates to characterize emissions; sought to improve consistency in estimates among multiple pollutants
➢Local-scale EI improvements
- Steel Mill Study – emissions test data, validate process emissions & controls
- LADCO Nonroad Study – improved local activity for commercial marine (CMV) and railroad (RR)
- Solvent Study – updated use statistics
- Link-based mobile emissions – produced criteria & toxic emissions using CONCEPT [1] and input data from SEMCOG local network for gridded, hourly, link-level emissions by vehicle class with highly resolved temporal profiles for traffic volume and VMT mix

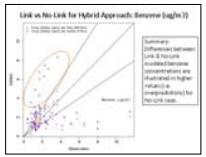
➢Emissions Modeling Improvements
- 1 km spatial surrogates and other improved land use based inventory data







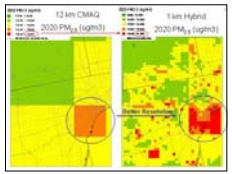
Mobile Source Emissions Link-Based Application: Detroit Network



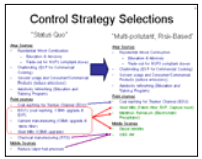
Air Quality Modeling

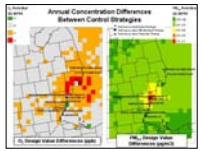
AERMOD [1] Receptor and Emission Modeling Domains
Detroit urban area: 36 x 48 km;
Receptors every 1 km

CMAQ [1] v4.6.1 - modeled at 12 km
'Hybrid' generates local gradients
- incorporates advantages of CMAQ & AERMOD



Control Strategy Analysis
Compare Multi-pollutant based approach to a 'Status Quo' Approach:
- 'Status Quo' because controls were selected to achieve separate O_3 and $PM_{2.5}$ attainment goals based on least-cost criteria





Conclusion

➢**Benefits-Related Insights** [1]
- Fine-scale analyses yield an improved:
  - Estimate of total benefits
  - Characterization of health impacts to specific sub-populations
  - Estimate of distribution of health impacts across locations
- Improved benefits estimates can help us maximize net benefits by applying controls to:
  - Sources nearest population centers
  - Sources nearest susceptible populations

➢**Detroit Multi-pollutant Pilot Project showed the value of . . .**
- Developing a MP modeling platform
- Developing a "Conceptual Model" to understand the MP nature of air quality issues an area
- Collecting local-scale information including emissions, AQ modeling, control and health data

➢**Demonstrated that our "Multi-pollutant, Risk-Based" (MPRB) Control Strategy achieved:**
- Same or greater reductions of PM2.5 & O3 at monitors
- Improved air quality regionally and across urban core for O3, PM2.5, and selected air toxics
- Approximately 2x greater benefits for PM2.5 & O3
- Reduction in non-cancer risk; VOC controls could also be prioritized based on toxics risks
- More cost effective and beneficial

➢**Next Steps: Review results and 'lessons learned' with state and local agencies that are developing multi-pollutant air quality management approaches**

Acknowledgements

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Lake Michigan Air Directors Consortium (*LADCO*

Contractors –Computer Science Corporation (CSC); Environ; ECR

References:

(1) Models:
CONCEPT - Consolidated Community Emissions Processing Tool
CMAQ - Community Multiscale Air Quality Modeling System;
AERMOD – AERMIC Dispersion Model;
BenMAP – Environmental Benefits and Mapping Analysis Program;
HEM-3 – Human Exposure Model V3